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The Green Revolution and Infant Mortality in India^{*}

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ABSTRACT

We use a difference in differences approach to show that the adoption of High Yielding Varieties (HYV) reduced infant mortality in India. This holds even comparing children of the same mother. Children of mothers whose characteristics predict higher child mortality, rural children, boys, and low-caste children benefit more from HYV adoption. We find no obvious evidence that parental investments respond to HYV adoption. We find little evidence of selection into child bearing in response to HYV adoption.

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1 INTRODUCTION

Between 1960 and 2000, India’s infant mortality rate dropped from 163.8 per 1,000 live births to 66.6 per 1,000 live births. This impressive decline took place over the same decades as India made astounding gains in agricultural productivity from 0.86 tons per hectare for wheat in 1960 to 2.79 tons per hectare in 2000, in large part due to research and implementation efforts that took place during the Green Revolution. By examining the relationship between agricultural productivity gains and infant mortality, this paper sheds new light at the intersection of two major developments in India and also extends prior work that has identified several factors behind poor child health outcomes across the developing world: inadequate health care seeking and participation by distressed mothers in the labour market (Bhalotra, 2010), *in utero* factors (Currie and Vogl, 2013), low levels of public expenditure on health infrastructure (Paxson and Schady, 2005; Cutler, Knaul, Lozano, Méndez, and Zurita, 2002; Maluccio et al., 2005) and lower per capita income (Pritchett and Summers, 1996), among others. Our analysis stretches from 1966 to 1998 and covers much of India, allowing us to examine the impacts of these gains for a country where agriculture is the main source of income for a large fraction of the population.¹

Our study focuses on perhaps the single most important source of agricultural productivity gains: the adoption of high yielding varieties (HYV) of seeds. The adoption of HYV began in the late 1960s in India with the advent of the Green Revolution and has continued ever since. The gains from HYV adoption (henceforth HYV adoption) are documented in the literature on the Green Revolution (e.g. Evenson and Gollin (2003a)). In this paper, we show the reduced form relationship between HYV adoption and infant mortality across districts of India over time. In particular, a one standard deviation increase in the share of cultivated area planted to HYV in a child’s year of birth reduces infant mortality by 0.50 percentage points. This is substantial relative to the average infant mortality over births of 9.5% in our sample.

Our empirical strategy addresses standard concerns that can arise in examining the effect of HYV adoption on infant mortality. For instance, individuals might sort into high HYV adoption districts based on the characteristics of those districts. If the characteristics that are associated with sorting also affect infant mortality, then this could bias our results. Furthermore, individuals born in different years could be subjected to economic

¹According to the FAO, some 70% of rural Indian households depend on agriculture for their main source of income. See <http://www.fao.org/india/fao-in-india/india-at-a-glance/en/>

events, such as recessions, which could drive part of the correlation between HYV adoption and infant mortality. To address these concerns, our baseline specification includes district fixed effects that absorb all time-invariant characteristics of the district which are associated with HYV adoption and also affect infant mortality. It also includes year of birth fixed effects that account for any shocks to infant mortality, such as recessions, that coincide with the year of birth but affect macroeconomic conditions beyond the level of a district. We also include, in alternative specifications, state-specific linear time trends or state by year fixed effects in our baseline estimates. The first takes into account any unobserved trending variables that may vary by state-specific birth cohorts, and the second accounts for any annual pattern in birth outcomes that may differ across states.

Our baseline specification, therefore, compares two children from the same district who are subjected to different levels of HYV adoption based on their year of birth, over and above any unobserved shocks to infant mortality that vary by the year of birth, and any long-run trends (or annual patterns) in infant mortality in the state of birth.

To uncover the mechanisms through which HYV adoption affects infant mortality, we use three different strategies. First, we examine heterogeneity in the effect of HYV adoption across various sub-groups. We find that HYV adoption has a greater effect on children born to mothers with characteristics that generally predict greater child mortality. The effect is also greater for a child born to a low caste mother, which suggests that children from poorer households are helped more by HYV adoption. However, the effect is smaller when the child born is a girl. Finally, the effect is greater for a child born in a rural area, implying that the effect of HYV adoption was primarily mediated through agricultural incomes and general development of rural areas.

Next, we examine whether parents respond to HYV adoption by altering their investments in child health during the pre and post natal stages. We find no evidence that parental investments mediate the effect of HYV adoption on infant mortality; hence, rural health infrastructure that might correlate with the green revolution might not have played an important role in this instance. Finally, we investigate whether HYV adoption affects infant mortality by influencing the profile of mothers who give birth. We find little evidence that predetermined maternal or child characteristics respond to HYV adoption.

We carry out several empirical exercises to show the robustness of our baseline results. First, we show that replacing district fixed effects with mother fixed effects gives results that are close to the baseline estimates. That is, when comparing two children born to the

same mother, the child whose birth coincided with a greater prevalence of HYV cultivation is more likely to survive, net of other trends captured by our year fixed effects and state specific linear time trends (or state by year fixed effects). Then, we address the concern of broad secular trends in infant mortality at the district level influencing our results. To account for such trends we include district-specific linear time trends and state-by-year fixed effects. Using an event-study specification that interacts eventual HYV adoption with year fixed effects, we show that there are no differential time trends in mortality prior to the Green Revolution. Since prior research has shown that the green revolution affected fertility ([Foster and Rosenzweig, 2007](#)), we re-do our analysis by birth order to show that our results are robust when we only include first borns (since most women in our sample go on to have at least one child). We also conduct robustness exercises where we predict the spread of the green revolution based on soil characteristics and aquifer depth ([Zaveri et al., 2016](#); [D’Agostino, 2017](#)) – controlling for these characteristics does not alter our results. Finally, we report results using an alternative source of district level administrative data on infant mortality.

We contribute to the broader literature on the microeconomics of technology adoption. For example, there are cross-country studies that analyze the social, economic and political impacts of technology adoption across both agricultural and non-agricultural sectors. [Nunn and Qian \(2011\)](#) examine the effects of potato adoption in Europe, and [Bustos, Caprettini, Ponticelli, et al. \(2016\)](#) investigate the impact of agricultural productivity gains on non-agricultural economic activity. There are also more focused studies examining whether agricultural science and research impacts economic or social outcomes at a smaller geographical scale ([Hornbeck and Keskin, 2014](#); [Fan, Zhang, and Zhang, 2000](#); [Meinzen-Dick, Adato, Haddad, and Hazell, 2003](#); [Dalrymple, 2008](#)). Finally, the literature identifying sources of child health outcomes is also well developed ([Bhalotra, 2010](#); [Maluccio et al., 2005](#); [Paxson and Schady, 2005](#); [Cutler, Knaul, Lozano, Méndez, and Zurita, 2002](#); [Pongou, Salomon, and Ezzati, 2006](#)).

However, to our knowledge, very few studies exist that connect productivity gains from agricultural technology adoption to child health outcomes in micro-economic data. The first contribution of this paper is, therefore, to add critical evidence in this space by examining the impacts of HYV adoption on infant mortality in India. Perhaps closest in spirit to our paper is the work of [McCord et al. \(2017\)](#) who use geospatial data from multiple countries in the DHS to examine how adoption of HYV affects child mortality. Their work however, does not cover India, and does not have enough variation to find

statistically significant effects in South Asian countries. Methodologically, we are also able to clearly show lack of pre-trends in infant mortality prior to the adoption of HYV seeds. Our paper also contributes to this literature by examining these impacts across different areas of the same country. This has the advantage, over cross-country studies, of restricting the range of potential omitted variables and of comparing areas that have similar political and administrative set-ups ([Banerjee and Iyer, 2005](#)). Moreover, the data on parental investments in our panel allows us to test the extent to which households and institutions are able to respond to HYV adoption by increasing their investments in child health. Another related paper is the work of [Brainerd and Menon \(2014\)](#) who examine the specific relationship between fertilizer agrichemicals in water and child health in India. Since the use of HYV seeds are typically accompanied by increased fertilizer use, in light of the findings of [Brainerd and Menon \(2014\)](#), we interpret our results as being net of the effects of fertilizer use.

The rest of the paper is organized as follows. In Section 2 we provide the background to our study. In particular, we document the development of the HYV of two major crops—wheat and rice—and their diffusion in India. We also postulate mechanisms that link HYV adoption to health outcomes. Section 3, outlines our empirical strategy. Section 4 describes the infant mortality data, the HYV data and the procedure we use to match the infant mortality data to the HYV data. Section 5 discusses our results. Section 6 investigates mechanisms linking HYV adoption to infant mortality, and Section 7 concludes.

2 BACKGROUND

The Green Revolution can be credited to the cross-breeding experiments of the International Rice Research Institute (IRRI), set up in the Philippines in 1961, and its sister institution, the International Centre for Maize and Wheat Improvement (CIMMYT) that was set up in Mexico in 1967 ([Gollin, Hansen, and Wingender, 2016](#), p. 4). The development of hybrid varieties of wheat happened around the same time as that of rice. Cross-breeding experiments were initiated at the Rockefeller Foundation program for wheat improvement in Mexico, the precursor of CIMMYT, and by 1961 the first semi-dwarf varieties of the crop were released worldwide. Rice and wheat HYV were more successful in raising productivity than the HYV of other crops. For instance, yield increases from HYV adoption in crops such as sorghum and millet were smaller than those for rice and

wheat ([Estudillo and Otsuka, 2013](#), p. 22). This was because scientists had already developed a critical mass of knowledge about rice and wheat in particular, which did not exist for other crops ([Evenson and Gollin, 2003a](#)). [Gollin, Hansen, and Wingender \(2016\)](#) state that “in spite of the rapid success of the research in rice and wheat it took much longer for the green revolution to be extended to other crops, reflecting large differences in the initial stock of scientific knowledge.”

Once the HYV of rice and wheat were introduced in India in 1965, their adoption was fairly rapid. We consider the case of rice in North India as an example. The share of cultivated area planted to HYV of rice in North India went from an average of 11% in the period 1965-69 to an average of 82% in the period 1975-79 ([Barker, Herdt, and Rose, 1985](#), p. 218). This represents a sudden and sharp increase in HYV adoption on historical timescales. However, such an aggregate trend masks substantial variation in adoption rates across states. In Punjab, for instance, more than 99% of the land cultivated with rice was planted to HYV by the end of the first decade after introduction ([Barker, Herdt, and Rose, 1985](#), p. 149). This was despite the state being a minor producer of rice. On the other hand, in the primarily rain-fed states of eastern India—Western Bengal, Bihar and Orissa—the share of HYV acreage averaged only around 25% at around the same time ([Barker, Herdt, and Rose, 1985](#), p. 149). One reason for the variable rates of HYV adoption across states was the differing prevalence of input factors such as irrigation systems or reliable rainfall ([Evenson and Gollin, 2003a](#)). Another was the adaptability of the HYV to location-specific characteristics such as diseases, pests, and abiotic stresses ([Evenson and Gollin, 2003a](#)). Finally, factors such as income, investment, human capital, and agricultural policies also mattered for differential adoption rates ([Gollin, Hansen, and Wingender, 2016](#), p. 11).

A number of possible mechanisms connect HYV adoption to health outcomes. First is an increase in food production due to the higher productivity of HYV. An increase in food production decreases food prices, resulting in higher caloric intake. A higher caloric intake leads to gains in health and life expectancy ([Evenson and Gollin, 2003a](#)). These health gains are especially acute for children. [Evenson and Gollin \(2003a\)](#) credit the productivity gains from HYV adoption with raising the health status of between 32 to 42 million pre-school children, and with lowering infant and child mortality worldwide. Second, is an increase in agricultural incomes earned from productivity enhancements through HYV adoption. Income can affect child health in several ways – for example, it

can reduce the opportunity cost of maternal time, thereby causing mothers to seek health care services.

A positive income shock can also lower distress labour market participation² of mothers and improve prospects of health in early-life (Bhalotra, 2010). An increase in incomes can induce parental investments in child health outcomes either in the form of ‘compensatory’ or ‘reinforcing’ behaviour once child quality is revealed (Almond and Mazumder, 2013; Bharadwaj, Eberhard, and Neilson, 2017). The profile of mothers who give birth can be linked to income shocks in such a way so as to reduce infant mortality. In particular, a decrease in income can cause high-risk mothers to delay their fertility decisions (Dehejia, Lleras-Muney, et al., 2004). Finally, a negative income shock can cause a dramatic collapse in public expenditures on health and, thereby, adversely affect child health outcomes (Paxson and Schady, 2005; Cutler, Knaul, Lozano, Méndez, and Zurita, 2002; Maluccio et al., 2005).

3 EMPIRICAL STRATEGY

3.1 BASELINE SPECIFICATION

In order to test for the impact of HYV adoption on infant mortality, we use ordinary least squares (OLS) to estimate the following reduced form equations:

$$Mortality_{isdy} = \beta ShareHYV_{dy} + x'_{isdy}\gamma + \eta_y + \delta_d + \zeta_s \times y + \epsilon_{isdy} \quad (1)$$

and

$$Mortality_{isdy} = \beta ShareHYV_{dy} + x'_{isdy}\gamma + \eta_y + \delta_d + \zeta_{sy} + \epsilon_{isdy} \quad (2)$$

Here, $Mortality_{isdy}$ is an indicator for the death of child i in the first twelve months after birth, born in year y , whose mother is surveyed in district d in state s . In our main

²Distress labour market participation of mothers is defined as maternal labour supply during recessions for the purpose of consumption smoothing (Bhalotra, 2010).

results $ShareHYV_{dy}$ is the fraction of all cultivated land in district d that is planted to HYV in the year of birth y . It measures the extent of HYV adoption in district d in the year of birth y . β is the coefficient of interest, and we expect its sign to be negative. Additionally, we include several important sets of fixed effects. The first are district fixed effects, δ_d , that control for all time invariant characteristics of the district. For instance, if a district has lower level of HYV adoption as well as higher infant mortality due to its bad soil quality, then to obtain better estimates of the effect of technology on infant mortality we need to be able to control for the influence of the poor soils. A fixed effect at the district level would not only control for the influence of the soil quality, but would also capture all other time invariant characteristics by including a dummy variable for the district. The second set of fixed effects we include are year of birth fixed effects, η_y , that account for any time-specific shocks such as earthquakes, macroeconomic conditions, flooding, disease outbreaks or dust storms that affect all districts equally in the year of birth.

In addition to the above fixed effects we also include either state by year fixed effects, ζ_{sy} , or state-specific linear time trends $\zeta_s \times y$, in our baseline specification.³ Here, ζ_s are state fixed effects. The first accounts for general annual variation in birth outcomes that may vary across states, and the second accounts for possible unobserved trending variables that may vary by state-specific birth cohort. Finally, we cluster standard errors by district. In particular, we aggregate districts to those that existed in 1966, merging together districts that were split after the start of our principal data on HYV.

Hence, for identification, we compare children from the same district who are exposed to varying levels of HYV by virtue of their date of birth, over and above any unobserved shocks to mortality that vary by year of birth, and any long-run trends (or annual patterns) in that child's state of birth.

Finally, we add a vector of controls, $x'_{isd y}$, to our baseline specification that includes birth order, a dummy for whether the child born is female, a dummy for whether the child born is a multiple birth, a dummy for DHS round, mother's age in survey, mother's age in survey squared, a dummy for whether child is born in urban area, a dummy for the mother's religion, a dummy for the mother's caste, rainfall, and temperature. The controls for rainfall and temperature are added to isolate the impacts of exposure to the

³Note that the state-by-year fixed effects ζ_{sy} make the year fixed effects η_y redundant. We include them above for expositional clarity.

Green Revolution from the broader impacts of the weather during the child’s year of birth.

We also carry out several robustness exercises to further corroborate our baseline results. First, we replace the district fixed effects with more stringent mother fixed effects. These restrict identification to comparisons of children born to the same mother. The inclusion of this alternative fixed effect has little impact on the baseline results. Second, in addition to the district fixed effects we also include district time trends. Again, the results are of the same sign and magnitude as our baseline estimates, and remain significant at the 5 percent level. Third, we switch our measure of HYV adoption from being based on data in the VDSA dataset to being based on data in the India Agricultural and Climate Dataset (IACD). The sign and significance of our baseline results are similar when we switch the measure. Fifth, we cluster the standard errors by state in DHS, or survey cluster in DHS, instead of district. Again the results remain unchanged.

It is important to note here that our paper does not include a structural model that describes the mechanism(s) for our baseline results. Therefore, we interpret our main result as a “reduced form” relationship between HYV adoption and infant mortality. We explore mechanisms later in the paper by examining heterogeneity in responses to HYV adoption, as well as other outcomes that respond to it.

3.2 FLEXIBLE SPECIFICATION

As mentioned in Section 1, we also make use of an alternative source of data on infant mortality that stretches back to 1951 (almost 18 years before the start of the Green Revolution in 1969) in order to rule out any pre-existing trends in infant mortality when estimating the impact of HYV adoption on infant mortality. We estimate a flexible specification that takes the following form:

$$Mortality_{sdy} = \Gamma_y(Year_y \times ShareHYV_{d,r}) + \delta_d + \zeta_{sy} + \epsilon_{sdy} \quad (3)$$

Here, $Mortality_{sdy}$, is the number of infant deaths per 1000 live births in district d in state s in year y . $(Year_y \times ShareHYV_{d,r})$ are the interactions between year dummies and the fraction of land planted to HYV in district d in a reference year r . We report

estimates for $r \in \{1970, 1975, 1980, 1985\}$. δ_d are district fixed effects, and ζ_{sy} are state-by-year fixed effects. We cluster our standard errors at the district level. Γ_y is the vector of estimated interaction coefficients that reveal the relationship between HYV adoption and infant mortality in each year. If, for instance, the adoption of HYV from the Green Revolution decreased infant mortality then we would expect the estimated coefficients to be more or less constant over time for the years before the Green Revolution and then to decline sharply after the start of the Green Revolution. Note also that since $ShareHYV_{d,r}$ is time invariant and also because equation (3) includes state and year fixed effects, the estimated Γ_y coefficients must be measured relative to a baseline year, which we take to be 1957, the first year of data.

4 DATA

In this section, we describe the data sources that were used in the empirical analysis. Moreover, where necessary, we describe the construction of the main variables in the analysis.

4.1 ADOPTION OF HYV

4.1.1 VILLAGE DYNAMICS IN SOUTH ASIA

We take the annual data on the area planted to HYV from the Village Dynamics in South Asia (VDSA) dataset. The VDSA dataset is a panel that covers 281 districts across nineteen states of India over the period 1966 to 2009. It includes annual district-level information on the area (in hectares) planted to high yielding varieties of six major crops—wheat, rice, maize, sorghum, finger millet, and pearl millet. Additionally, it has annual information on area cultivated (in hectares) and production (in tonnes) for 5 major and 19 minor crops. Aside from the data on agricultural outcomes, the VDSA dataset also has information on socioeconomic, climatic, edaphic, and agro-ecological variables. The nineteen states covered in the dataset are Assam, Himachal Pradesh, Kerala, Chhattisgarh, Jharkhand, Uttarakhand, Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. The base year for districts in the VDSA panel is 1966. This means that data from child districts formed after 1966 are assigned to their respective parent

districts to form a comparable sample of districts from 1966 to 2009 that is based on the 1966 district boundaries.

To compute our main explanatory variable—the adoption of HYV—we aggregate the area planted to HYV of all the major crops in each district in the year of birth. We then divide the sum by the total area cultivated in the district in the year of birth in order to compute the share of cultivated area planted to HYV.

4.1.2 INDIAN AGRICULTURE AND CLIMATE

The Indian Agriculture and Climate Dataset (IACD) is a panel that covers 271 districts across thirteen states of India. Like the VDSA panel it has annual district level data on the area planted to high yielding varieties in hectares of the five major crops for the period 1957 to 1987. Since the IACD starts from 1957 this means that it has annual data on agricultural outcomes for several years before the introduction of HYV in the late 1960s. The states covered by the IACD are Haryana, Punjab, Uttar Pradesh, Gujarat, Rajasthan, Bihar, Orissa, West Bengal, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Madhya Pradesh.

We use the same procedure we followed for the VDSA dataset to compute our main explanatory variable. First, we sum the area planted to HYV of all the major crops in each district in the year of birth. Then, we divide the sum by the total area cultivated in each district in the year of birth to compute the share of cultivated area planted to HYV.

4.2 INFANT MORTALITY

4.2.1 DEMOGRAPHIC AND HEALTH SURVEY DATA

The data on our outcomes of interest come from two rounds of the Demographic Health Surveys conducted in India in 1992-93 and 1998-99, respectively.

The data in the DHS surveys come in three formats:

1. The *Individual Recodes* survey women who are aged between 15 and 49. These are nationally representative surveys that contain information on several variables that we

use. These include the woman’s year of birth, her level of education, whether she lives in a rural area, her age, her caste, and her religion.

2. The *Births Recodes* are the complete birth histories of the women surveyed in the individual recodes. We use these data for our baseline results. Specifically, we use the child’s year of birth, birth order, an indicator for a multiple birth, a dummy for female, and the length of the child’s life. The recodes have births as far back as the 1950s, several years before the first year in which the data on HYV of crops starts in the VDSA dataset in 1966.

3. The *Children’s Recodes* include more information on a smaller sample of children. Women are asked about births in the previous five years. There is information on early life investments such as vaccinations and breastfeeding. There is also information on prenatal investments including care from doctors and the circumstances of the child’s birth. We use all of these variables in our empirical analysis.

4.2.2 VITAL STATISTICS OF INDIA

An alternative source of data on infant mortality that we use are the annual Vital Statistics of India reports. These reports contain information on registered live births, deaths, infant deaths and still births for each district, broken down by locality (i.e. rural-urban) and gender. We use the number of infant deaths and the number of births to compute our measure of infant mortality at the district level. The formula we use to compute our infant mortality measure is as follows:

$$\text{Infant Mortality Rate}_{dy} = \frac{\text{No. of infant deaths in district (d) in year (y)}}{\text{No. of live births in district (d) in year (y)}} \times 1000 \quad (4)$$

4.3 ADDITIONAL CONTROLS

We use both average monthly rainfall in millimeters and average monthly temperature in degrees Celsius in a child’s year of birth as controls. These are obtained from [Matsuura and Willmott \(2009\)](#).

4.4 MATCHING DHS TO HYV DATA

We use the names of the districts surveyed in the DHS to assign each child the share of HYV acreage of the district where the child was born. Where districts have split in the DHS but not in the VDSA data, children are assigned the agricultural data values from the parent district. Because the HYV acreage numbers reported in the VDSA data for one district in 1986 (The Dangs) are implausibly large relative to total acreage, we drop these observations from the data.

4.5 SUMMARY STATISTICS

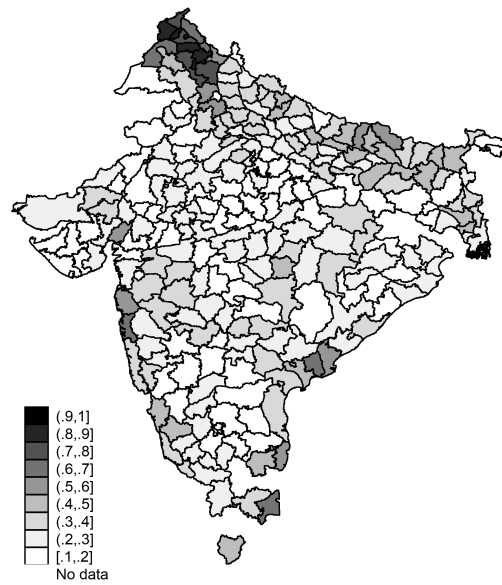
We show the summary statistics used in this paper in Table 1. Infant mortality over births in our data averages 9.5%. The average for child mortality over births is higher at 13%. The share of HYV acreage over births averages 29%. As Figure 1 shows there is substantial heterogeneity in HYV adoption and infant mortality across districts in our panel. Moreover, there is an inverse relationship between HYV adoption and infant mortality: districts with the lowest mean infant mortality over births are also the ones that have the highest mean shares of HYV acreage over births. It is important to note here that in Appendix Table A4 we show robustness of our baseline results to a range of clustering assumptions: *administrative region as recorded in the DHS*, *state* and *DHS survey cluster*. Indeed, as Appendix Table A4 shows, standard errors are more or less indistinguishable using either of the three alternatives.

Table 1 also provides information on the characteristics of mothers in our sample. The average age of mothers in the sample is 34 years and the average birth order is nearly 3. Also, mothers have low levels of education (an average of 2.17 years) and tend to marry young (an average age of 16.2 years). In our baseline results we control for maternal characteristics, such as a mother's education, age, religion and caste, since they can influence infant mortality.

Additionally, Figure 2 shows declining infant mortality across both High and Low-HYV adoption districts over the period 1966 to 1998. The trend is indicative of there being no systematic differences in infant mortality between High and Low-HYV adoption districts prior to the introduction of HYV in the late 1960s. After these are introduced, a visible gap opens up between the infant mortality rates of the two sets of districts.

FIGURE 1: HYV adoption and Infant Mortality: Heterogeneity

Mean district HYV use across all births



Mean infant mortality across all births

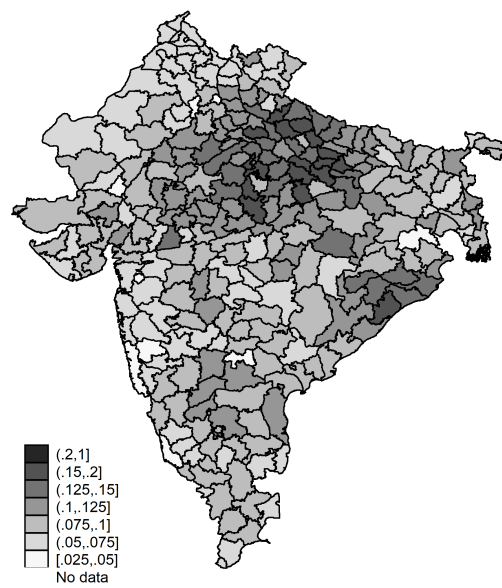
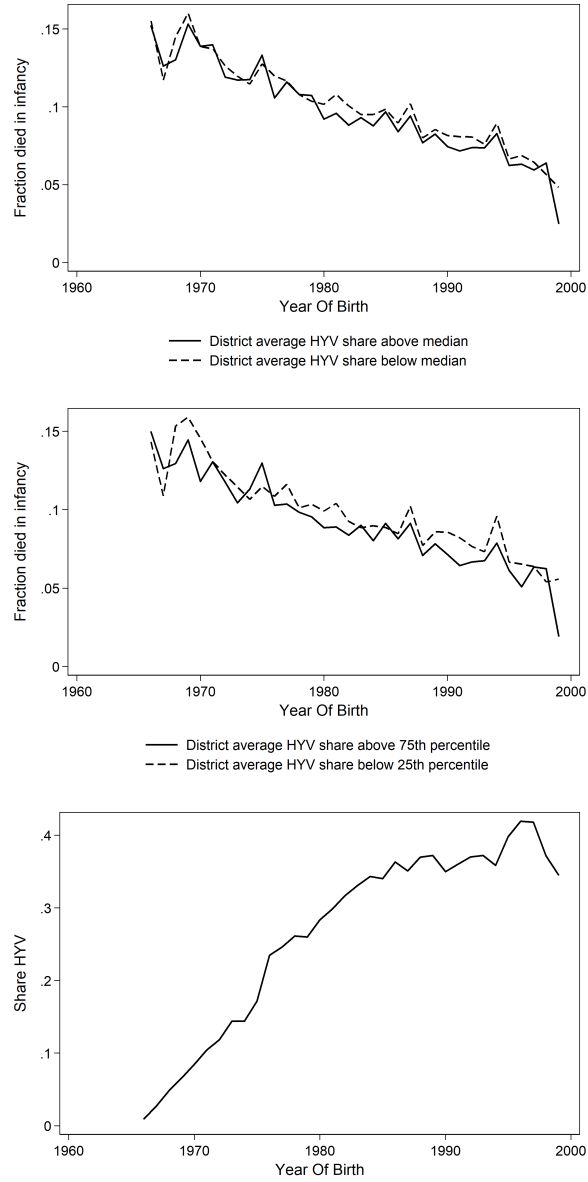


FIGURE 2: HYV adoption and Infant Mortality: Trends



Notes: We use two alternative definitions for distinguishing between High and Low-HYV districts. In the first we define a High (or Low) HYV district in a given year as being one where the fraction of cultivated area planted to HYV is above (or below) its median value in that year. In the second we define a High (or Low) HYV district in a given year as being one where the fraction of cultivated area planted to HYV is above its 75th percentile (or below the 25th percentile) value in that year.

5 RESULTS

In Table 2 we show the results from estimating our baseline regression in equations (1) and (2). The table shows the impact of HYV adoption on infant–within 12 months of birth–mortality. The results show a substantial and significant reduction in infant mortality from increased HYV adoption. The first two columns include state-specific linear time trends and the last two columns include state by year fixed effects. As we move from the first to the second column or from the third to the fourth column, we find that including controls for rainfall, temperature, the child’s attributes, mother’s characteristics and a dummy for DHS survey round makes almost no difference to the size and precision of the impact of HYV adoption on infant mortality. This means that it is unlikely that omitted variables correlated with HYV adoption are driving our results (Altonji, Elder, and Taber, 2005).

Interpreting the magnitude of the coefficient on HYV adoption in column 2 of Table 2, we find that a one standard deviation increase in HYV adoption leads to a 0.50 percentage point decrease in infant mortality, or approximately 5.3% of the mean⁴. Our magnitude is comparable to the magnitudes of other determinants of infant and child mortality found in the literature. These include the elasticity of rural infant mortality with respect to aggregate income of -0.33 in India (Bhalotra, 2010), the long-run income elasticity of infant and child mortality with respect to per capita income of between 0.2 and 0.4 in developing countries (Pritchett and Summers, 1996), the 3.27 percent reduction in American infant mortality due to a decrease in the use of bituminous coal for heating (Barreca, Clay, Deschenes, Greenstone, and Shapiro, 2016) and the 0.51 percent reduction in American infant mortality from an increase in the unemployment rate (Dehejia, Lleras-Muney, et al., 2004).

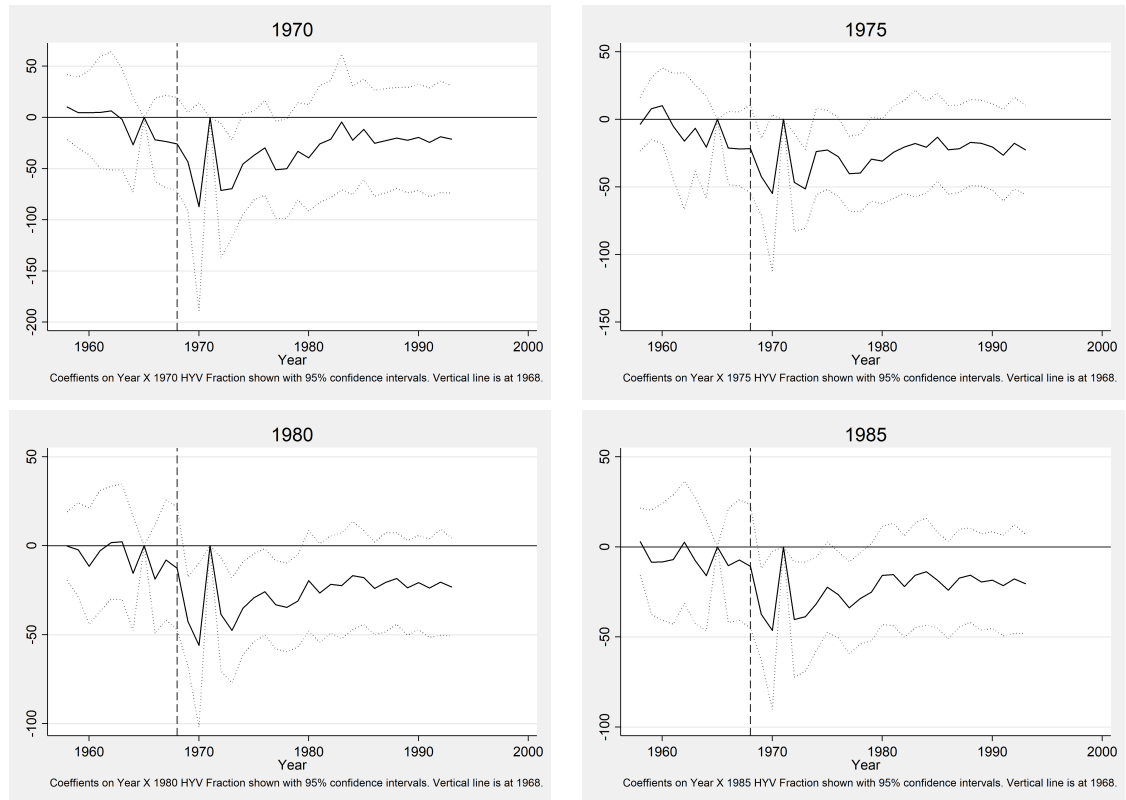
In Figure 3 we show the results from estimating our flexible specification in equation 3. Our purpose in estimating the flexible specification is to provide evidence for the lack of pre-trends in infant mortality between areas where HYV adoption was higher or lower before the Green Revolution. Figure 3 consists of four separate plots with each plot showing a variation of the same flexible specification. To create the plots we interact year of birth dummies with our measure for Green Revolution intensity (i.e. fraction of

⁴To arrive at this, we multiply the standard deviation of HYV adoption from Table 1 (0.21) by the coefficient (-0.024), and then multiply the resulting number by 100 to convert from deaths per birth to percentage points.

land planted to HYV in 1970, 1975, 1980, or 1985) and plot the resulting year and green revolution intensity interaction coefficients and their associated confidence intervals.

It is clear from the figure that the fraction of land planted to HYV is uncorrelated with trends in infant mortality prior to the Green Revolution. We mark 1968 as the start of the Green Revolution in these figures, since that was the first year in which the fraction of cropped acreage planted to HYV surpassed 5% in the World Bank's India Agriculture and Climate Data Set. There is a decline in infant mortality starting around the start of the Green Revolution and that is most pronounced in the districts where HYV adoption is more widespread. This suggests that areas where the Green Revolution was more intense were not on a different trajectory in terms of their infant mortality compared to areas where the Green Revolution was less intense prior to the Green Revolution. Moreover, it was only around the time of the Green Revolution that infant mortality declined more rapidly in areas where Green Revolution was more intense.

FIGURE 3: HYV fraction and infant mortality



Notes: Each point is the interaction coefficient from a regression where year of birth dummies are interacted with the fraction of land planted to HYV in the stated year. The regression controls for district fixed effects, year fixed effects, and state-by-year fixed effects.

6 MECHANISMS

Our analysis in the previous section has shown that HYV adoption reduces infant mortality across districts in India. While limitations of the available data restrict us from uncovering all possible mechanisms that explain how HYV adoption affects infant mortality, nevertheless, we use (1) heterogeneity in the effect across sub-groups, (2) the behavioural response of parents in terms of investments in early-life health outcomes and (3) the response of additional childhood health outcomes to reduce the set of plausible explanations.

6.1 HETEROGENEOUS EFFECTS

In Table 3 we explore heterogeneity in the effect of HYV adoption on infant mortality. The first four columns of the top panel include the interaction of HYV adoption with child gender. We find that HYV adoption is more effective in reducing the infant mortality of boys relative to girls. Specifically, in column 2 of the top panel the impact of HYV adoption on the infant mortality for girls is only about half of that for boys. There are two possible explanations for such a result. First, since male fetuses are more fragile than their female counterparts ([Gualtieri and Hicks, 1985](#); [Kraemer, 2000](#)) it is likely that the biological improvements caused by HYV adoption are greater for boys than for girls. That is: because boys start from a lower health endowment, the marginal return to any additional investment may be greater for them. It could also be the case that the greater reduction in infant mortality for boys is due to gender-biased parental investments in early-life health. If parents use the additional income generated from HYV adoption to invest disproportionately in the early-life health of boys then this could explain the heterogeneous effect of HYV adoption across gender.

Columns 5 to 8 of the top panel include the interaction of HYV adoption with a dummy for the child being born to a lower caste mother. The coefficient estimates on the interaction show that children from lower caste mothers benefit more from HYV adoption. The results are consistent with poorer (i.e. lower caste) mothers lacking the financial resources for undertaking investments in early-life health. They also reflect the importance of caste networks in facilitating access to health facilities ([Munshi and Rosenzweig, 2009](#)).

The last four columns of the top panel and the first four columns of the bottom panel report results for heterogeneity by two important characteristics of mothers in our sample—

age and education. The results show that HYV adoption leads to a smaller decrease in infant mortality for older and more educated mothers. Conversely, younger and less educated mothers benefit more from HYV adoption. Such a result suggests that it is mothers whose observable characteristics correlate negatively with child survival who gain more from HYV adoption.

The last four columns of the bottom panel show that there is a greater reduction in infant mortality amongst rural children, relative to urban ones. Specifically, in column 10 of the bottom panel, the impact of HYV adoption on the infant mortality of rural children is only about one-fifth of that on urban children. Such a result is not surprising as HYV are an agricultural innovation that mainly affected incomes of rural households.⁵

Most of the productivity gains from the adoption of HYV in India have been concentrated in either rice or wheat for two reasons. First, the HYV for these crops are more effective in raising productivity relative to other crops (Evenson and Gollin, 2003b, p. 461). As mentioned earlier, this was because scientists had developed a critical mass of knowledge about these two crops which they had not developed for other crops (Evenson and Gollin, 2003b). Second, wheat and rice are the most extensively cultivated crops in the country. In Table 4 we test for crop-specific heterogeneity in the impact of HYV adoption. We find a negative effect of HYV adoption on infant mortality for both wheat and rice, though the latter is only significant with state-specific trends, and not with state-by-year fixed effects. We also find similar effects for sorghum and pearl millet. There is no impact for maize and finger millet.

6.2 BEHAVIOURAL RESPONSES AND HEALTH OUTCOMES

In this section, we investigate whether the effect of HYV adoption is mediated through greater parental investments in child health. Parental investment responses have been cited in the literature as a mechanism for other determinants of early-life health (Almond and Mazumder, 2013). We would expect HYV adoption to raise parental investments in child health for two main reasons. First, an increase in agricultural incomes associated with HYV adoption could cause parental investments in health during the prenatal and

⁵In Table A24 in the Appendix, we show that this is not simply due to differences between children of farmers and other children. Using whether a woman reports that her partner is self-employed in agriculture as a proxy for whether the observation is the child of a farmer, we show the effect is larger for this sub-sample, though the interaction is neither large nor significant.

neonatal stages. Second, HYV adoption could reduce the opportunity cost of maternal time, thereby causing mothers to engage in seeking health care services ([Bhalotra, 2010](#)).

In Table 5 we find no obvious evidence of HYV adoption affecting investments in child health. The top two panels of Table 5 examine the impact of HYV adoption on investments (vaccinations) undertaken between 12 to 23 months after birth. For most investments we find no significance for the impacts. The only exceptions are the ‘Polio 1’ and ‘DPT 1’ vaccinations, as well as the “any vaccination” indicator. The third panel of Table 5 shows how pre-natal and at-birth investments respond to HYV adoption. Since such investment decisions are made before the child’s birth, they reflect the impact of HYV adoption on ‘access’ to health care services, rather than ‘compensatory’ investments by parents once child quality is revealed ([Bharadwaj, Eberhard, and Neilson, 2017](#)). We find no evidence that HYV adoption is related to pre-natal and at-birth investments. In sum, then, there is not much evidence of greater parental investments explaining the effects that we find.

Finally, in the bottom panel of Table 5 we examine the impact of HYV adoption on early childhood health outcomes beyond the infancy period. We do this to learn more about the health profile of children who survive the infancy period. If HYV adoption helped only the weakest children survive, then we would expect those children whose survival depended upon HYV adoption to have worse health outcomes. We do not find much evidence for HYV adoption being negatively associated with health outcomes of surviving children such as height, weight, birth size, recent fever and recent diarrhoea, but we do find a significantly negative effect for recent coughs.

6.3 SELECTION

HYV adoption can also affect infant mortality by influencing the profile of mothers who give birth. For instance, [Dehejia, Lleras-Muney, et al. \(2004\)](#) and [Bhalotra \(2010\)](#) find that recessions cause high-risk mothers to delay their fertility decisions. In our case, if parents with both education and experience decide to have more children in response to HYV adoption, then such self-selection of parents with characteristics that predict child survival into child bearing could explain why HYV adoption reduces infant mortality. We, therefore, test for whether selective fertility based on either parental or child characteristics can explain the effect of HYV adoption on infant mortality. To do so, we estimate equation (1) and (2) with parental and child characteristics as the outcome variables.

Our test for selection is motivated from [Buckles and Hungerman \(2013\)](#). In Table 6 we find that HYV adoption has little effect on predetermined characteristics of mothers or children. In one specification, there is a positive impact on the mother’s education that is significant at the 10% level. It also appears that children are more likely to be female in districts where HYV adoption has expanded: this may reflect greater survival until birth, though our main results in Table 2 do control for child gender.

6.4 PRINCIPAL ROBUSTNESS CHECKS

In this section we perform several empirical exercises to show the robustness of our main result. First, in Table 7, we replace the district fixed effects with mother fixed effects. Hence, we are comparing children born to the same mother but at different times of HYV penetration. Columns 1-4 of Table 7 show results consistent with our previous results on the impact of HYV penetration on infant mortality across siblings.

Third, in Table 8, we replace the state-specific time trends or state-by-year fixed effects from our baseline specification with district time trends to account for any unobserved trending variables that could vary by district-specific birth cohort. Despite the inclusion of the district time trends the results have the same sign and magnitude as our baseline estimates, and remain significant at the 5 percent level.

6.5 ADDITIONAL ROBUSTNESS CHECKS

In addition to the above robustness exercises, we perform a series of additional robustness tests in the Appendix. The results in the Appendix tables are organized in the same way as our baseline results in Table 2, meaning that, for each variant of the baseline specification, there are two columns: one for the parsimonious model without controls and the other for the model with controls.

In Appendix Table A1 we show results for three different variants of our baseline specification. Columns 1 to 4 replace infant mortality (death within 12 months of birth) with child mortality (death within five years of birth) as the outcome variable. The magnitudes of the coefficients show that HYV adoption causes a greater reduction in child mortality relative to infant mortality. Columns 5 to 8 use an alternative HYV adoption measure that replaces the denominator with initial (1970) acreage as opposed to contemporary (in the same year) acreage. The magnitudes of the estimated coefficients on the alternative

measure of HYV adoption are somewhat smaller, but the sign and the significance are the same. Columns 9 to 12 use another alternative HYV adoption measure that uses the natural logarithm of the area planted to HYV. Since we do not normalize HYV area by acreage this may be a more imprecise measure of HYV adoption. Even then, our results are still significant and have the same sign as the baseline estimates.

Next, we use Appendix Table A2 to show that our results are not dependent on the nature of the relationship between HYV adoption and infant mortality being linear. In columns 1 to 4 we use a quadratic functional form for our empirical specification where we include the square of the HYV adoption measure in addition to the HYV adoption measure. Both the magnitude and sign on the estimated coefficients of the HYV adoption measure are similar to those for our baseline specification. However, the positive sign on the coefficient for the square of the HYV adoption measure is evidence for there being non-linearity in the relationship between HYV adoption and infant mortality. Columns 5 to 8 use deciles of the HYV adoption measure to show that, relative to the omitted, lowest decile, higher deciles of the HYV adoption measure reduce infant mortality more.

Additionally, Appendix Table A3 shows that our baseline results are not sensitive to the exclusion of districts with extreme values of HYV adoption or child mortality. In the top panel of Table A3 we remove from the sample those districts that have a value of child mortality that is either below the first quintile or above the fifth quintile. The magnitudes of the coefficients for HYV adoption are, again, similar to the baseline. However, the effect of HYV adoption is somewhat larger once districts that have extreme values of child mortality are removed from the sample. The bottom panel of Table A3 removes from the sample districts that have mean HYV adoption that is either below the first quintile (columns 1 to 4) or above the fifth quintile (columns 5 to 8). Again, the results remain broadly similar to the baseline despite the exclusion of extreme HYV adoption values from the sample and despite the reduction in sample size.

In Appendix Table A4, we cluster standard errors either by DHS districts, by DHS survey cluster, or by state, instead of by districts in the agricultural data. Again, our baseline results are robust to these alternative ways of clustering.

Appendix Table A5 shows the robustness of our baseline results to the use of alternative data on HYV from the IACD. In the top panel (Panel A) we replace values for the HYV adoption measure that are missing in the VDSA data with non-missing values based on data from the IACD. In the middle panel (Panel B) we replace the missing values for the

HYV adoption measure in the IACD data with non-missing values based on the VDSA data. In the bottom panel (Panel C) we take an average of the HYV adoption measure based on the data given in the VDSA and the IACD. In all cases the sign and significance of the results remain the same as our baseline estimates. Moreover, the magnitudes do not change by much despite the inclusion of the IACD data in our sample.

We consider the possibility that the determinants of HYV adoption may have been responsible for differential trends in infant mortality across districts in Appendix Tables A6 and A7. In Table A6, we identify the cross-sectional correlates of HYV adoption at five points in time: 1966, 1970, 1975, 1980, 1985.⁶ The variables we consider are all taken from the VDSA data. In particular, we consider aquifer thickness, topsoil thickness, soil pH, soil type, latitude, longitude, normal annual rainfall, initial population density, and initial shares of area cultivated in wheat and rice. In Table A6, we show that HYV adoption was more widespread in districts with greater aquifer thickness and topsoil thickness, neutral pH, a handful of soil types, lower latitudes and, in some specifications, greater initial shares planted to wheat and rice.

In Table A7, we show that controlling for these correlates of HYV adoption does not explain away our main results. Because these are time-invariant, we control for them in alternative specifications by i. interacting them with the child’s year of birth, and ii. interacting them with fixed effects for the child’s year of birth. Columns (1) through (4) report results controlling for determinants interacted with year of birth, and columns (5) through (8) report results controlling for determinants interacted with year of birth fixed effects. We select the correlates that are particularly consistent in their significance across columns of Table A6: dummies for soil types 1, 16, and 18, aquifer thickness greater than 150 meters, topsoil thickness greater than 300 centimeters, neutral soil pH, and initial shares planted in wheat and rice. Across specifications, results are little changed from the baseline.

In Table A8, we consider the “strict exogeneity” assumption inherent in a fixed effects analysis such as ours, that there is no correlation between HYV adoption in district i in year t and the error terms at all leads and lags within a district. We enter additional leads and lags of HYV adoption into the regression as controls, from two years before the child is born until two years after. While we find evidence that prior lags also predict infant mortality (HYV adoption two years before birth enters with a significant and negative

⁶Our sample falls to 270 districts as aquifer and topsoil depth are not available for Etah district.

sign), there is no correlation between child survival and HYV adoption after the child is born, and the coefficient on HYV adoption in the child's year of birth is largely unaffected.

Because our sample size occasionally differs across tables and across columns due to the availability of different controls, we use Table A9 to report our main results from Table 2, our mother fixed effects results from Table 7, and our district trends results from Table 8 on a consistent sample. Results here are similar to the corresponding tables. Similarly, we use Tables A10 and A11 to show that our results for specific crops (Table 4) and predetermined characteristics (Table 6) are also largely unchanged if we restrict the sample to be the same across columns.

In Table A12, we further consider the issues of strict exogeneity and the unobserved determinants of HYV adoption by addressing the relationship between HYV adoption and lagged weather shocks. In a panel of districts, we estimate the following three equations:

$$ShareHYV_{dt} = \alpha + \beta Rainfall_{dt-1} + \delta_d + \eta_t + \epsilon_{dt}, \quad (5)$$

$$\Delta ShareHYV_{dt} = \alpha + \beta Rainfall_{dt-1} + \delta_d + \eta_t + \epsilon_{dt}, \quad (6)$$

$$\Delta ShareHYV_{dt} = \alpha + \beta Rainfall_{dt-1} + \gamma ShareHYV_{dt-1} + \delta_d + \eta_t + \epsilon_{dt}. \quad (7)$$

That is, we consider whether the share of land planted to HYV in district d in year t ($ShareHYV_{dt}$) responds to lagged rainfall $Rainfall_{dt-1}$, conditional on district and year fixed effects (δ_d and η_t). We show results with the outcome treated in levels and in first differences, as well as with a lagged dependent variable. Across specifications, the standardized estimates of β , i.e. $\hat{\beta}$ multiplied by the standard deviation of $Rainfall_{dt-1}$ and divided by the standard deviation of the outcome variable, are small, at less than 0.06 standard deviations in absolute magnitude. This suggests that time-varying omitted variables such as rainfall that might affect infant mortality are unlikely to be major sources of variation in our principal measure of HYV adoption.

In Tables A13 through A23 we address the fact that panel data constructed from cross-sections of fertility histories is likely to lead children born in later years to have higher birth orders. In Table A13, we restrict the sample to first births only. In Table A14, we restrict the sample to children born before 1975. In Table A15, we restrict the sample to children born between 1970 and 1980. In Table A16, we restrict the sample to children born between 1980 and 1990. Table A17 restricts the sample to the first two births of

mothers who have at least two births. Table A18 uses only the first round of the DHS data, and Table A19 uses only the second round.

Across all these sample restrictions, the estimated coefficients are negative and have similar magnitudes to our baseline estimations. They are not, however, significant in all cases. Where this is the case, it is often because the sample restriction gives a sample much smaller than in our baseline, and the coefficient estimates remain of a magnitude that would be significant at conventional levels if the precision were the same as in our baseline estimates from Table 2. That is, the loss of significance here is due not to reduced coefficients but to larger standard errors.

In our baseline regressions, we include birth order as a linear control. In Table A20, we control instead for birth order fixed effects. In Table A21, we replace these with district \times birth order fixed effects. In both cases, our results are similar to our baseline. In Table A22, we interact our main measure of HYV adoption with birth order. In three of four specifications, we find no heterogeneity by birth order. In column (4), we find that the effect is somewhat smaller for children from higher birth orders, though the effect size is less than 10% that of share planted to HYV. In Table A23, we show that controlling for a quadratic in mother's age at the child's birth and its square has little effect on our main results.

Finally, in Table A25, we show that controlling for the lagged log yield of a district's principal crop (defined by maximum area in 1966) has little effect on our main results.

7 CONCLUSION

This paper shows that the adoption of HYV reduces infant mortality in India during the period 1966 to 1998. While there exist studies that have examined the microeconomic effects of technology adoption and identified sources of poor health outcomes in developing countries, our paper contributes to such a literature in several ways. First, by connecting agricultural productivity gains from HYV adoption with infant mortality, we focus on the role played by technological change in influencing health outcomes in developing countries. Second, by restricting our study to India, we are able to compare areas that have similar political and administrative arrangements, which is not the case in cross-country studies. Third, we use heterogeneous impacts of HYV adoption across various sub-groups to show that it is mothers whose characteristics predict less child survival, children born to lower

caste mothers, children who are born as girls and children born in rural areas who are most advantaged by HYV adoption. Fourth, we show that parental investments in either early life health or the health of children who survive beyond infancy are not correlated with HYV adoption.

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Table 1. Summary Statistics

	(1)	(2)	(3)	(4)	(5)
	Mean	s.d.	Min	Max	N
<i>Identifiers</i>					
Round	32.7	9.50	23	42	388,093
Unique Mother ID	74,657	39,831	1	136,383	388,093
District ID VDSA	159	93.2	1	319	388,093
<i>Mother Characteristics</i>					
Current Age - Respondent	34.3	8.01	13	49	388,093
Education In Single Years	2.17	3.76	0	22	387,551
Age At First Marriage	16.1	2.79	8	48	388,093
Can Read And Write	0.20	0.40	0	1	347,025
Mother Age Squared	1,241	552	169	2,401	388,093
Completed Primary	0.31	0.46	0	1	388,093
Completed Secondary	0.17	0.37	0	1	388,093
Urban	0.25	0.43	0	1	388,093
Low Caste	0.34	0.47	0	1	386,072
Tribal	0.093	0.29	0	1	386,072
Muslim : Muslim and Hindu Sample Only	0.12	0.33	0	1	367,995
<i>Child Characteristics</i>					
Birth Order Number	2.87	1.88	1	16	388,093
Year Of Birth	1,984	7.75	1,966	1,999	388,093
Child Multiple	0.013	0.11	0	1	388,093
Child Female	0.48	0.50	0	1	388,093
Child Died As Infant	0.095	0.29	0	1	388,093
<i>Green Revolution</i>					
Total HYV Area / Total Cultivated Area	0.29	0.21	0	0.96	331,838
<i>Weather Controls</i>					
Rainfall (in millimetres)	86.0	45.7	2.03	465	387,786
Temperature (in degree celsius)	25.6	1.73	4.92	29.8	387,786

Table 2. Impact of HYV cultivation on infant mortality

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.025*** (0.007)	-0.024*** (0.007)	-0.027*** (0.009)	-0.027*** (0.009)
Observations	331,838	330,577	331,838	330,577
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table 3. Heterogeneous effects of HYV cultivation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Child Died As Infant											
Total HYV Area / Total Cultivated Area	-0.032*** (0.008)	-0.031*** (0.008)	-0.034*** (0.010)	-0.034*** (0.009)	-0.019** (0.008)	-0.017** (0.007)	-0.022** (0.009)	-0.019** (0.009)	-0.061*** (0.020)	-0.091*** (0.020)	-0.058*** (0.021)	-0.088*** (0.021)
Interaction	0.014*** (0.005)	0.015*** (0.005)	0.015*** (0.005)	0.015*** (0.005)	-0.016** (0.007)	-0.020*** (0.007)	-0.016** (0.007)	-0.020*** (0.007)	0.002** (0.001)	0.004*** (0.001)	0.002* (0.001)	0.004*** (0.001)
Observations	331,838	330,577	331,838	330,577	330,627	330,577	330,627	330,577	331,838	330,577	331,838	330,577
Mean outcome	0.0981	0.0979	0.0981	0.0979	0.0981	0.0981	0.0981	0.0979	0.0981	0.0979	0.0981	0.0979
Interaction variable	Child female		Child female		Mother low caste		Mother low caste		Mother age at marriage		Mother age at marriage	
	Child Died As Infant											
Total HYV Area / Total Cultivated Area	-0.032*** (0.008)	-0.031*** (0.007)	-0.033*** (0.009)	-0.034*** (0.009)	-0.027*** (0.008)	-0.025*** (0.008)	-0.029*** (0.010)	-0.028*** (0.009)	-0.030*** (0.008)	-0.030*** (0.007)	-0.031*** (0.009)	-0.032*** (0.009)
Interaction	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.003*** (0.001)	0.009 (0.011)	0.003 (0.010)	0.011 (0.011)	0.004 (0.010)	0.022*** (0.008)	0.024*** (0.008)	0.021*** (0.008)	0.023*** (0.008)
Observations	331,352	330,091	331,352	330,091	313,226	312,027	313,226	312,027	331,838	330,577	331,838	330,577
Mean outcome	0.0981	0.0979	0.0981	0.0979	0.100	0.100	0.100	0.100	0.0981	0.0979	0.0981	0.0979
Interaction variable	Mother education		Mother education		Mother Muslim		Mother Muslim		Urban		Urban	
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A	Yes	Yes	N/A	N/A	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table 4. Effects of specific crops

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Child Died As Infant											
Crop HYV Area / Total Cultivated Area	-0.020* (0.011)	-0.020* (0.011)	-0.029* (0.016)	-0.029* (0.016)	-0.051** (0.022)	-0.051** (0.022)	-0.048** (0.023)	-0.048** (0.023)	0.002 (0.038)	0.002 (0.038)	0.009 (0.033)	0.009 (0.033)
Observations	330,837	330,837	330,837	330,837	331,025	331,025	329,779	329,779	329,079	329,079	307,134	307,134
Crop	Rice		Wheat		Sorghum		Pearl Millet		Maize		Finger Millet	
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A
State YOB trends	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
State YOB FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table 5. Impact of HYV cultivation on child investments and outcomes

	(1)		(2)		(3)		(4)		(5)		(6)	
<i>Vaccines received A:</i>	Tetanus		BCG		DPT 1		Polio 1		DPT 2			
Total HYV Area / Total Cultivated Area	-0.052 (0.107)	-0.035 (0.124)	-0.061 (0.043)	-0.011 (0.046)	-0.122*** (0.043)	-0.096** (0.048)	-0.144*** (0.047)	-0.118** (0.051)	-0.075 (0.048)	-0.030 (0.051)		
Observations	35,136	35,136	34,648	34,648	34,546	34,546	34,695	34,695	34,521	34,521		
<i>Vaccines received B:</i>	Polio 2		DPT 3		Polio 3		Measles		Any			
Total HYV Area / Total Cultivated Area	-0.127** (0.052)	-0.077 (0.051)	-0.027 (0.049)	-0.003 (0.055)	-0.090* (0.052)	-0.060 (0.053)	-0.077 (0.049)	-0.035 (0.044)	-0.159*** (0.051)	-0.092* (0.054)		
Observations	34,671	34,671	34,521	34,521	34,671	34,671	34,093	34,093	26,328	26,328		
<i>Care received:</i>	Pre-natal doctor		Doctor at birth		Breastfeeding duration		Prenatal visits		Iron tablet			
Total HYV Area / Total Cultivated Area	0.041 (0.042)	0.026 (0.050)	0.003 (0.042)	-0.009 (0.054)	-1.463 (1.444)	0.257 (1.258)	0.400* (0.238)	0.355 (0.288)	0.040 (0.044)	0.032 (0.054)		
Observations	35,380	35,380	35,316	35,316	35,109	35,109	35,468	35,468	35,317	35,317		
<i>Health outcome:</i>	Birth size		Recent diarrhea		Recent fever		Recent cough		Weight		Height	
Total HYV Area / Total Cultivated Area	0.068 (0.073)	0.132 (0.084)	0.019 (0.035)	0.013 (0.042)	-0.011 (0.040)	-0.002 (0.041)	-0.081** (0.038)	-0.071* (0.041)	-0.455 (0.350)	-0.205 (0.410)	-1.737 (1.552)	-1.018 (1.861)
Observations	35,116	35,116	32,614	32,614	32,617	32,617	32,620	32,620	28,400	28,400	23,192	23,192
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A
State YOB trends	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
State YOB FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table 6. Selective fertility and survival to birth

	(1)		(2)		(3)		(4)		(5)	
<i>Mother characteristics A</i>	Low Caste		Tribal		Age in survey		Age at first marriage		Education	
Total HYV Area / Total Cultivated Area	-0.020 (0.016)	-0.025 (0.019)	0.000 (0.007)	-0.003 (0.010)	-0.145 (0.232)	-0.265 (0.279)	0.129 (0.093)	0.143 (0.115)	0.182 (0.120)	0.241* (0.145)
Observations	330,627	330,627	330,627	330,627	331,838	331,838	331,838	331,838	331,352	331,352
<i>Mother characteristics B</i>	Muslim		Completed primary		Completed secondary		Urban		Literate	
Total HYV Area / Total Cultivated Area	0.009 (0.011)	0.014 (0.013)	0.018 (0.016)	0.022 (0.020)	0.015 (0.012)	0.022 (0.013)	0.008 (0.013)	0.005 (0.017)	0.019 (0.016)	0.022 (0.019)
Observations	313,226	313,226	331,838	331,838	331,838	331,838	331,838	331,838	299,708	299,708
<i>Child characteristics</i>	Birth order		Female		Multiple					
Total HYV Area / Total Cultivated Area	0.012 (0.068)	0.017 (0.086)	0.022** (0.010)	0.028** (0.013)	0.001 (0.004)	0.001 (0.004)				
Observations	331,838	331,838	331,838	331,838	331,838	331,838				
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A
State YOB trends	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
State YOB FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Controls	No	No	No	No	No	No	No	No	No	No

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS.

Table 7. Main results with mother fixed effects

	(1)	(2)	(3)	(4)
	Child Died As Infant			
Total HYV Area / Total Cultivated Area	-0.021** (0.009)	-0.021** (0.009)	-0.015 (0.011)	-0.020* (0.011)
Observations	331,838	330,577	331,838	330,577
Fixed effects	Mother ID + year of birth			
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table 8. Main results with trends for districts

	(1)	(2)
	Child Died As Infant	
Total HYV Area / Total Cultivated Area	-0.020** (0.008)	-0.019** (0.008)
Observations	331,838	330,577
District FE	Yes	Yes
Birth Year FE	Yes	Yes
Controls	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A1. Alternative variable definitions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Mortality measure											
HYV Measure	-0.032*** (0.009)	-0.031*** (0.009)	-0.031*** (0.011)	-0.032*** (0.010)	-0.020*** (0.007)	-0.020*** (0.006)	-0.020** (0.008)	-0.020*** (0.008)	-0.003*** (0.001)	-0.003*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)
Observations	331,838	330,577	331,838	330,577	334,821	333,554	334,821	333,554	343,077	341,503	343,077	341,503
Alternative measure	LHS: Child mortality				RHS: 1970 area as denominator				RHS: In HYV area			
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A	Yes	Yes	N/A	N/A	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A2. Alternative functional forms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Child Died As Infant							
Total Hyv Area / Total Cultivated Area	-0.048*** (0.018)	-0.047*** (0.017)	-0.052** (0.022)	-0.051** (0.021)				
Total Hyv Area / Total Cultivated Area Squared	0.031 (0.021)	0.031 (0.020)	0.033 (0.024)	0.032 (0.023)				
HYV Decile 2					-0.007* (0.004)	-0.006* (0.004)	-0.010** (0.004)	-0.009** (0.004)
HYV Decile 3					-0.001 (0.004)	-0.001 (0.004)	-0.005 (0.005)	-0.005 (0.005)
HYV Decile 4					-0.008* (0.004)	-0.007* (0.004)	-0.012** (0.005)	-0.011** (0.005)
HYV Decile 5					-0.010** (0.004)	-0.009** (0.004)	-0.012** (0.005)	-0.012** (0.005)
HYV Decile 6					-0.011** (0.005)	-0.011** (0.004)	-0.014*** (0.005)	-0.014*** (0.005)
HYV Decile 7					-0.012** (0.005)	-0.012** (0.005)	-0.015*** (0.006)	-0.015*** (0.006)
HYV Decile 8					-0.013** (0.005)	-0.012** (0.005)	-0.016*** (0.006)	-0.016*** (0.006)
HYV Decile 9					-0.017*** (0.005)	-0.016*** (0.005)	-0.019*** (0.006)	-0.018*** (0.006)
HYV Decile 10					-0.013** (0.006)	-0.012** (0.005)	-0.015** (0.007)	-0.015** (0.006)
Observations	331,838	330,577	331,838	330,577	331,838	330,577	331,838	330,577
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes	No	No	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A3. Results with outliers removed

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Child Died As Infant							
Total Hyv Area / Total Cultivated Area	-0.027*** (0.009)	-0.026*** (0.008)	-0.027** (0.011)	-0.026*** (0.010)	-0.025*** (0.008)	-0.024*** (0.008)	-0.030*** (0.010)	-0.029*** (0.009)
Observations	261,609	260,437	261,609	260,437	268,252	267,780	268,252	267,780
Removed	Child mortality Q1				Child mortality Q5			
	Child Died As Infant							
Total Hyv Area / Total Cultivated Area	-0.015* (0.009)	-0.014 (0.008)	-0.018* (0.010)	-0.017* (0.010)	-0.039*** (0.012)	-0.039*** (0.012)	-0.043*** (0.015)	-0.043*** (0.014)
Observations	265,464	264,450	265,464	264,450	265,478	264,512	265,478	264,512
Removed	HYV Q1				HYV Q5			
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes	No	No	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A4. Alternative clustering

	(1)	(2)	(3)	(4)
	Child Died As Infant			
Total HYV Area / Total Cultivated Area	-0.025**	-0.024**	-0.027**	-0.027**
<i>s.e. clustered by district in DHS</i>	(0.007)	(0.007)	(0.009)	(0.009)
<i>s.e. clustered by state</i>	(0.009)	(0.009)	(0.011)	(0.010)
<i>s.e. clustered by survey cluster</i>	(0.007)	(0.007)	(0.009)	(0.008)
Observations	331,838	330,577	331,838	330,577
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A5. Incorporation of older World Bank data

	(1)	(2)	(3)	(4)
	Child Died As Infant			
<i>Panel A. Missing filled using World Bank data</i>				
Total HYV Area / Total Cultivated Area	-0.022*** (0.007)	-0.023*** (0.007)	-0.029*** (0.009)	-0.027*** (0.009)
Observations	344,854	336,937	344,854	336,937
	Child Died As Infant			
<i>Panel B. World Bank filled using VDSA</i>				
Total HYV Area / Total Cultivated Area	-0.025*** (0.006)	-0.024*** (0.006)	-0.031*** (0.008)	-0.027*** (0.008)
Observations	344,854	336,937	344,854	336,937
	Child Died As Infant			
<i>Panel C. Average of World Bank and VDSA</i>				
Total HYV Area / Total Cultivated Area	-0.027*** (0.007)	-0.026*** (0.007)	-0.033*** (0.009)	-0.030*** (0.009)
Observations	344,854	336,937	344,854	336,937
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A6. Determinants of HYV cultivation

	(1)	(2)	(3)	(4)	(5)
	Total Hyv Area / Total Cultivated Area				
<i>Year</i>	1966	1970	1975	1980	1985
<i>Estimator</i>	OLS	OLS	OLS	OLS	OLS
Aquifer thickness > 150meters	0.005 (0.003)	0.095*** (0.026)	0.132*** (0.031)	0.169*** (0.036)	0.181*** (0.052)
Aquifer thickness 100-150meters	0.004 (0.004)	0.019 (0.018)	0.012 (0.025)	0.014 (0.030)	0.009 (0.038)
Topsoil thickness 25-50 centimeters	0.004 (0.005)	-0.017 (0.030)	0.034 (0.036)	0.057 (0.037)	0.075 (0.059)
Topsoil thickness 50-100 centimeters	0.002 (0.004)	-0.015 (0.029)	0.026 (0.031)	0.031 (0.032)	0.069 (0.055)
Topsoil thickness 100-300 centimeters	0.004 (0.004)	-0.006 (0.031)	0.033 (0.037)	0.051 (0.039)	0.037 (0.058)
Topsoil thickness > 300centimeters	0.005 (0.004)	0.037 (0.031)	0.129*** (0.037)	0.151*** (0.041)	0.178*** (0.062)
slightly alkali 5.5<pH<6.5	0.004 (0.003)	-0.013 (0.018)	-0.008 (0.023)	-0.037 (0.027)	-0.039 (0.036)
neutral 6.5<pH<7.5	-0.000 (0.003)	-0.045* (0.027)	-0.041 (0.030)	-0.085** (0.036)	-0.109** (0.046)
slightly acid 7.5<pH<8.5	-0.001 (0.003)	-0.017 (0.021)	-0.020 (0.026)	-0.050 (0.032)	-0.062 (0.039)
slightly acid 7.5<pH<8.5	0.002 (0.004)	-0.007 (0.031)	0.015 (0.038)	0.018 (0.044)	0.007 (0.059)
Soil Type 1	0.011** (0.005)	-0.015 (0.027)	0.090** (0.040)	0.128*** (0.041)	0.162*** (0.059)
Soil Type 2	-0.006 (0.004)	-0.026 (0.029)	0.001 (0.039)	-0.010 (0.043)	-0.023 (0.054)
Soil Type 3	-0.005 (0.005)	-0.005 (0.024)	0.043 (0.048)	0.004 (0.041)	0.042 (0.062)
Soil Type 4	-0.002 (0.003)	0.005 (0.016)	0.015 (0.026)	-0.001 (0.030)	0.046 (0.044)
Soil Type 5	-0.001 (0.005)	0.028 (0.026)	0.019 (0.031)	0.043 (0.034)	0.074 (0.049)
Soil Type 6	-0.004 (0.004)	0.007 (0.022)	0.009 (0.028)	0.009 (0.034)	0.016 (0.048)
Soil Type 7	-0.000 (0.003)	-0.001 (0.016)	0.018 (0.027)	0.013 (0.033)	-0.012 (0.038)
Soil Type 8	0.003 (0.007)	0.086** (0.038)	0.086* (0.046)	0.097* (0.052)	0.042 (0.073)

Table A6. (Continued)

	(1)	(2)	(3)	(4)	(5)
	Total Hyv Area / Total Cultivated Area				
<i>Year</i>	1966	1970	1975	1980	1985
<i>Estimator</i>	OLS	OLS	OLS	OLS	OLS
Soil Type 9	-0.006* (0.003)	-0.017 (0.024)	-0.010 (0.041)	0.034 (0.075)	-0.050 (0.064)
Soil Type 10	-0.001 (0.006)	0.113*** (0.043)	0.117* (0.063)	0.097 (0.098)	0.133 (0.109)
Soil Type 11	-0.003 (0.002)	-0.013 (0.020)	-0.035 (0.040)	-0.020 (0.040)	0.047 (0.061)
Soil Type 12	-0.003 (0.003)	-0.001 (0.027)	-0.079 (0.055)	-0.050 (0.071)	-0.081 (0.118)
Soil Type 13	-0.001 (0.005)	0.007 (0.036)	-0.004 (0.052)	-0.123 (0.077)	-0.175* (0.095)
Soil Type 14	-0.006 (0.005)	-0.016 (0.030)	-0.004 (0.044)	-0.007 (0.042)	-0.020 (0.064)
Soil Type 15	0.001 (0.002)	0.086** (0.034)	0.073* (0.038)	0.105** (0.041)	0.047 (0.048)
Soil Type 16	-0.003 (0.002)	0.034* (0.018)	0.050** (0.025)	0.080*** (0.030)	0.099** (0.038)
Soil Type 17	-0.003 (0.005)	0.000 (0.018)	0.054* (0.033)	0.087** (0.037)	0.064 (0.048)
Soil Type 18	-0.005 (0.005)	-0.084* (0.049)	-0.195*** (0.066)	-0.153* (0.079)	-0.204** (0.098)
Soil Type 19	-0.006 (0.004)	0.024 (0.024)	-0.008 (0.028)	-0.016 (0.035)	-0.030 (0.046)
Soil Type 20	0.015 (0.019)	0.040 (0.043)	0.069 (0.061)	0.086 (0.092)	0.093 (0.104)
Degrees Latitude	-0.001*** (0.000)	-0.005** (0.002)	-0.005* (0.003)	-0.007** (0.003)	-0.008* (0.005)
Degrees Longitude	-0.001 (0.001)	-0.004 (0.003)	-0.008** (0.004)	-0.012** (0.005)	-0.007 (0.006)
Normal Annual Rainfall (1957 to 1987)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000* (0.000)	0.000 (0.000)
Population Density in 1961	0.000 (0.001)	0.008 (0.007)	0.007 (0.007)	0.006 (0.007)	0.004 (0.008)
Percent Wheat in 1957	0.007 (0.010)	0.153* (0.080)	0.188 (0.120)	0.274* (0.141)	0.341* (0.200)
Percent Rice in 1957	0.014 (0.009)	0.071 (0.051)	0.123* (0.065)	0.199*** (0.073)	0.168* (0.091)
Observations	270	270	270	270	270

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Dependent variable is the fraction of all crops planted to HYV in the indicated year.

Table A7. Impact of HYV cultivation on infant mortality controlling for HYV determinants

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Child Died As Infant							
Total HYV Area / Total Cultivated Area	-0.025*** (0.008)	-0.024*** (0.008)	-0.027*** (0.010)	-0.027*** (0.009)	-0.029*** (0.008)	-0.029*** (0.008)	-0.030*** (0.010)	-0.031*** (0.010)
Observations	321,056	319,819	321,056	319,819	321,056	319,819	321,056	319,819
<i>HYV Determinants YOB trends</i>	Yes	Yes	Yes	Yes	No	No	No	No
<i>HYV Determinants YOB FE</i>	No	No	No	No	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes	No	No	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A8. Impact of Lag/Lead HYV cultivation on infant mortality

	(1)	(2)
	Child Died As Infant	
(Total HYV Area / Total Cultivated Area) $t + 2$	-0.002 (0.009)	0.001 (0.010)
(Total HYV Area / Total Cultivated Area) $t + 1$	0.013 (0.010)	0.003 (0.011)
(Total HYV Area / Total Cultivated Area) t	-0.026** (0.010)	-0.021* (0.011)
(Total HYV Area / Total Cultivated Area) $t - 1$	0.026*** (0.010)	0.018* (0.010)
(Total HYV Area / Total Cultivated Area) $t - 2$	-0.032*** (0.010)	-0.029*** (0.010)
Observations	304,143	304,143
District FE	Yes	Yes
Birth Year FE	Yes	N/A
State YOB trends	Yes	No
State YOB FE	No	Yes
Controls	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A9. Results with consistent sample - I

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(5)	(6)
	Child Died As Infant									
Total HYV Area / Total Cultivated Area	-0.026*** (0.007)	-0.024*** (0.007)	-0.028*** (0.009)	-0.027*** (0.009)	-0.021** (0.009)	-0.021** (0.009)	-0.016 (0.011)	-0.020* (0.011)	-0.020** (0.008)	-0.019** (0.008)
Observations	330,577	330,577	330,577	330,577	330,577	330,577	330,577	330,577	330,577	330,577
Fixed effects and/or trends	District + year of birth				Mother ID + year of birth				District + year of birth + trends for districts	
State YOB trends	Yes	Yes	No	No	Yes	Yes	No	No	No	No
State YOB FE	No	No	Yes	Yes	No	No	Yes	Yes	No	No
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A10. Results with consistent sample - II

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Child Died As Infant											
Crop HYV Area / Total Cultivated Area	-0.018 (0.011)	-0.018 (0.011)	-0.027* (0.016)	-0.027* (0.016)	-0.047* (0.024)	-0.047* (0.024)	-0.044* (0.024)	-0.044* (0.024)	0.010 (0.038)	0.010 (0.038)	0.009 (0.033)	0.009 (0.033)
Observations	304,329	304,329	304,329	304,329	304,329	304,329	304,329	304,329	304,329	304,329	304,329	304,329
Crop	Rice		Wheat		Sorghum		Pearl Millet		Maize		Finger Millet	
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A
State YOB trends	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
State YOB FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A11. Results with consistent sample - III

	(1)		(2)		(3)		(4)		(5)	
<i>Mother characteristics A</i>	Low Caste		Tribal		Age in survey		Age at first marriage		Education	
Total HYV Area / Total Cultivated Area	-0.022 (0.016)	-0.019 (0.019)	0.003 (0.007)	-0.004 (0.010)	-0.141 (0.236)	-0.220 (0.289)	0.117 (0.088)	0.139 (0.110)	0.165 (0.121)	0.197 (0.142)
Observations	282,812	282,812	282,812	282,812	282,812	282,812	282,812	282,812	282,812	282,812
<i>Mother characteristics B</i>	Muslim		Completed primary		Completed secondary		Urban		Literate	
Total HYV Area / Total Cultivated Area	0.006 (0.011)	0.010 (0.014)	0.013 (0.016)	0.017 (0.019)	0.017 (0.012)	0.020 (0.014)	0.010 (0.013)	0.014 (0.016)	0.010 (0.015)	0.014 (0.018)
Observations	282,812	282,812	282,812	282,812	282,812	282,812	282,812	282,812	282,812	282,812
<i>Child characteristics</i>	Birth order		Female		Multiple					
Total HYV Area / Total Cultivated Area	-0.009 (0.075)	0.004 (0.094)	0.021* (0.012)	0.025* (0.015)	0.001 (0.004)	0.001 (0.005)				
Observations	282,812	282,812	282,812	282,812	282,812	282,812				
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Birth Year FE	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A	Yes	N/A
State YOB trends	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
State YOB FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Controls	No	No	No	No	No	No	No	No	No	No

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS.

Table A12. Impact of Lag Rain on HYV Adoption

	(1) HYV Measure	(2) First Difference HYV Measure	(3)
(Annual Rainfall) $t - 1$	0.009267* (0.004806)	-0.007950* (0.004182)	-0.001866 (0.004570)
(Total HYV Area / Total Cultivated Area) $t - 1$			-0.333460*** (0.064823)
Observations	9,139	8,960	8,960
Standardized Coefficient	0.0233	-0.0533	-0.0125
1966 District FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS and are based on a panel from 1966 to 2009.

Table A13. Main results with sample restricted to first births only

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.021* (0.011)	-0.021* (0.011)	-0.028** (0.014)	-0.030** (0.014)
Observations	94,365	94,028	94,365	94,028
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A14. Main results with sample restricted to children born before 1975

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.034 (0.037)	-0.036 (0.036)	-0.046 (0.044)	-0.044 (0.042)
Observations	50,180	50,009	50,180	50,009
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A15. Main results with sample restricted to children born between 1970 and 1980

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.032* (0.018)	-0.037** (0.018)	-0.031 (0.021)	-0.039* (0.021)
Observations	108,484	108,083	108,484	108,083
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A16. Main results with sample restricted to children born between 1980 and 1990

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.030*** (0.011)	-0.030*** (0.010)	-0.030** (0.012)	-0.028** (0.012)
Observations	176,646	175,849	176,646	175,849
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A17. Main results with sample restricted to first two births of mothers with at least two births				
	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.012 (0.014)	-0.012 (0.014)	-0.015 (0.017)	-0.020 (0.017)
Observations	164,239	163,640	164,239	163,640
Fixed effects		Mother ID + year of birth		
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A18. Main Results with sample restricted to first round of the birth recodes (i.e. round==23)

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.031*** (0.010)	-0.032*** (0.010)	-0.025** (0.012)	-0.027** (0.012)
Observations	174,695	174,695	174,695	174,695
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A19. Main Results with sample restricted to second round of the birth recodes (i.e. round==42)

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.019* (0.010)	-0.018* (0.010)	-0.026** (0.012)	-0.026** (0.011)
Observations	157,143	155,882	157,143	155,882
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A20. Main Results with birth order fixed effects included

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.025*** (0.007)	-0.024*** (0.007)	-0.027*** (0.009)	-0.027*** (0.009)
Observations	331,838	330,577	331,838	330,577
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
<i>Birth Order FE</i>	Yes	Yes	Yes	Yes
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A21. Main Results with district-by-birth order fixed effects included

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.026*** (0.007)	-0.025*** (0.007)	-0.027*** (0.009)	-0.027*** (0.009)
Observations	331,838	330,577	331,838	330,577
District FE	Yes	Yes	Yes	Yes
<i>District Birth Order FE</i>	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A22. Heterogeneous effect of HYV cultivation with respect to child birth order

	(1)	(2)	(3)	(4)
	Child Died As Infant			
Total HYV Area / Total Cultivated Area	-0.030*** (0.009)	-0.032*** (0.009)	-0.032*** (0.010)	-0.035*** (0.010)
Interaction	0.002 (0.002)	0.003 (0.002)	0.002 (0.002)	0.003* (0.002)
Observations	331,838	330,577	331,838	330,577
Interaction variable	Child Birth Order		Child Birth Order	
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A23. Control for mother age and age squared

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.024*** (0.008)	-0.024*** (0.007)	-0.025*** (0.009)	-0.026*** (0.009)
Mother age at child's birth	-0.020*** (0.001)	-0.018*** (0.002)	-0.020*** (0.001)	-0.018*** (0.002)
Squared	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Observations	331,838	330,577	331,838	330,577
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A24. Heterogeneous effect of HYV cultivation with respect to parent's partner in agriculture

	(1)	(2)	(3)	(4)
	Child Died As Infant			
Total HYV Area / Total Cultivated Area	-0.022*** (0.008)	-0.023*** (0.008)	-0.024** (0.010)	-0.026*** (0.009)
Interaction	-0.006 (0.006)	-0.002 (0.006)	-0.006 (0.006)	-0.002 (0.006)
Observations	331,838	330,577	331,838	330,577
Interaction variable	Partner Self Employed In Agriculture		Partner Self Employed In Agriculture	
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.

Table A25. Control for lagged log yield of principal crop

	(1)	(2)	(3)	(4)
		Child Died As Infant		
Total HYV Area / Total Cultivated Area	-0.023*** (0.008)	-0.022*** (0.007)	-0.024** (0.010)	-0.024*** (0.009)
Lag log yield of principal crop	-0.000 (0.002)	-0.000 (0.002)	0.001 (0.002)	0.001 (0.002)
Observations	325,363	324,110	325,363	324,110
District FE	Yes	Yes	Yes	Yes
Birth Year FE	Yes	Yes	N/A	N/A
State YOB trends	Yes	Yes	No	No
State YOB FE	No	No	Yes	Yes
Controls	No	Yes	No	Yes

Notes: ***Significant at 1%, **Significant at 5%, *Significant at 10%. Standard errors clustered by district in parentheses, unless otherwise indicated. All regressions are OLS. Controls are rainfall, temperature, birth order, female, multiple, DHS round, mother's age in survey, mother's age in survey squared, urban, mother's religion, and mother's caste, unless otherwise indicated.